



R.C.A. INSTITUTES

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Technical Lesson 41

BALANCED ARMATURE LOUD SPEAKERS

The loud speaker is a device utilized to convert a varying current into varying air waves. When these varying air waves are impressed upon the human ear they produce the sensation of sound. The ultimate purpose of the loud speaker then, is to produce sound.

The reproducing units used to attain this result may be divided mainly into three types:

- (a) The electromagnetic type
- (b) The balanced armature type
- (c) The electrodynamic type

The first, explained in a previous lesson, is well known and, although it was not termed a loud speaker, nevertheless the explanation given in Lesson 20, sheet 7, and Lesson 22, sheet 1, thoroughly cover the fundamentals of this type of reproducing unit. If the receiver shown in Figure 1, Lesson 22, had a horn fitted to the cap of the unit, an electromagnetic type of loud speaker would have been constructed. The balanced armature type loud speaker unit is used in the construction of cone speakers and also in making many of the higher grade horn type speakers as, for instance, the exponential horn. This unit utilizes a powerful permanent horse shoe magnet, shown in Figure 1, with specially formed pole pieces which are secured to the ends of the magnet with machine screws.

The reason for the special pole pieces is to provide two magnetic poles of North polarity close to the armature on one side and two poles of South polarity on the opposite side. The armature supports a small energizing coil, the two outside leads of which connect to the output of the receiver. When no current is flowing through the energizing coil of the armature, the flux supplied by the permanent horse shoe magnet divides itself equally across the special "U" shaped pole pieces and, as a result of this even division of flux, the armature tends to remain in a stationary position and no movement of the loud speaker cone takes place.

When, however, a current passes through the windings of the armature coils an electromagnetic field will spring up about this coil and develop an N, or north pole, at one end of the armature coil winding and an S, or south pole, at the opposite end of the armature coil winding. Since the armature acts as a core to this coil it will also develop magnetic poles which will correspond to the electromagnetic poles of the coil.

To emphasize this point refer to Figure 2 which, in this instance, represents an armature coil. We will assume, for example, that an electric current passes through the coil in a downward direction. The top end of the coil will develop a north pole and the bottom will develop a south pole because the electrical law concerning the polarity of a helix or solenoid, (and that is exactly what the armature coil is), states that if a solenoid or electromagnet is so grasped with the right hand that the fingers point in the direction of the flow of electric current, the thumb will point to that end of the coil which is the N, or north pole, of the coil. Therefore if the top end of the coil in Figure 2 is of N polarity the bottom end must be of S polarity.

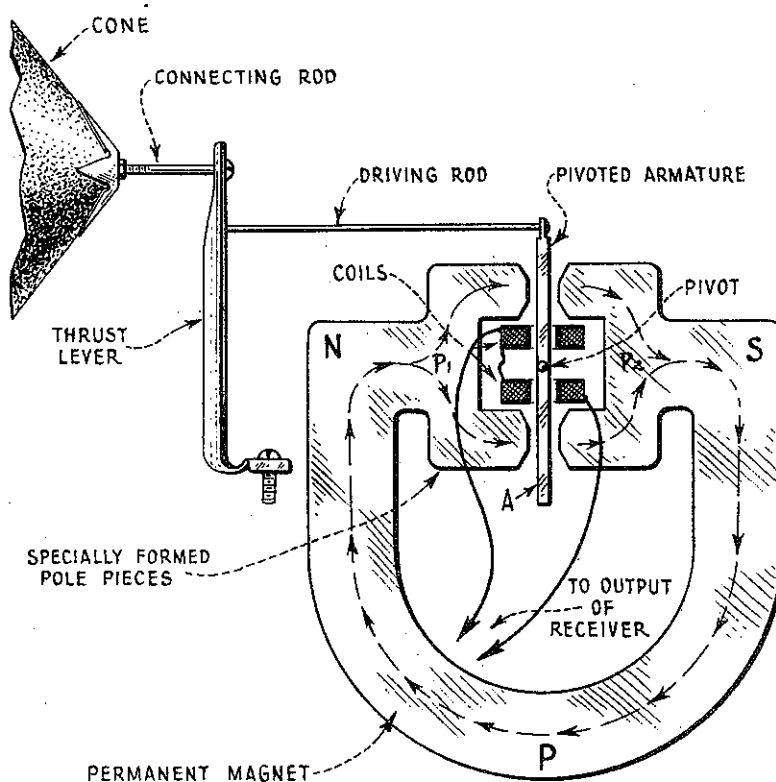


Figure 1

Now if we place an iron core in the coil as shown in Figure 3 the lines of force composing the field are concentrated in the iron core. This is true because iron offers a much lower resistance to the magnetic field than air. As a consequence we develop a strong field about the armature which takes the same polarity as the coil because, when an iron core is placed in a solenoid or helix, it does not change the polarity of the coil.

Now let us refer to Figure 1, wherein is shown the permanent magnet P, with the special pole pieces P-1 and P-2. Between these pole pieces is pivoted the armature A around which is wound a coil, C. In order to study the fundamental action of the armature let us suppose that a battery is so connected to coil C, Figure 4, that current flows downward; the polarity of the top of the coil is N, also the top of the

armature A will be N, and the bottom of the coil and armature will be of south polarity.

With the armature pivoted at its center the upper end of the armature will be repelled from the N pole of the permanent magnet and attracted to the south pole of the permanent magnet. The bottom end of the armature, because it is of S polarity, will be repelled from the S pole of the permanent magnet and attracted to the north pole of the permanent magnet. By reversing the armature coil connections at the battery the reverse action will take place. With the armature in motion the cone is made to move by means of the driving rod thrust pin and connecting rod as shown in Figure 1.

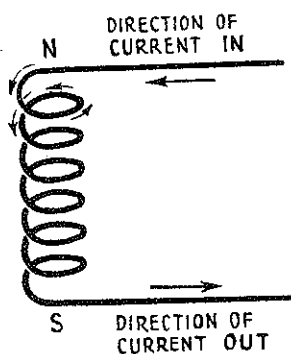


Figure 2

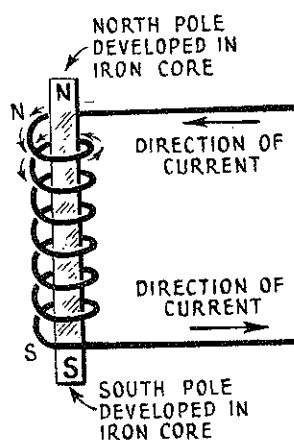


Figure 3

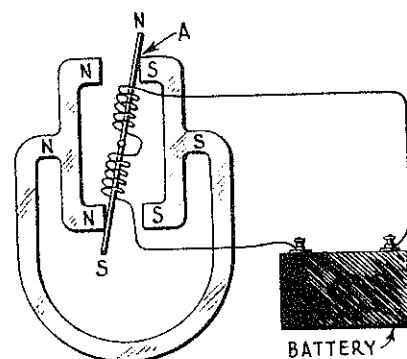


Figure 4

When the unit is operating in a receiving circuit the current does not actually change its direction. Practically, the plate current from the receiving set amplifying tube does not change in direction but it does rise and fall in value and, therefore, by the proper consideration being taken into account relative to the varying field caused by a varying current it can be readily understood that the armature of this type of unit will be in a continual state of motion moving toward the permanent magnet poles pieces and away from them because of the continually varying plate current values. The magnitude of the motion produced will naturally depend upon the power in the plate current of the amplifier tube, and the rate at which the motion takes place will be contingent upon the frequency at which the plate current changes.

Such a speaker unit may be used on any type of receiver and can be connected directly to the output of the set with disregard as to polarity, and without output coupling arrangements when using plate current voltages which pass current under 10 milliamperes. It is good practice, however, to utilize some method of coupling the output of the receiver to the loud speaker because much better results are obtained if only the changes of plate current, which correspond to the audible variations of the loud speaker, are allowed to flow through this unit. When the

speaker is connected in the plate circuit without the use of some form of coupling, the direct current from the plate voltage source is allowed to pass directly through the armature coil and it will tend to keep the armature more to one side of its normal position than to the other. Means are provided for adjusting the armature to compensate for a steady tension that would be caused by the direct current passing through the coil by forcing the armature in a direction opposite to the steady pull caused by the direct current, thereby maintaining a complete balance between the permanent magnet pole pieces under all normal working conditions.

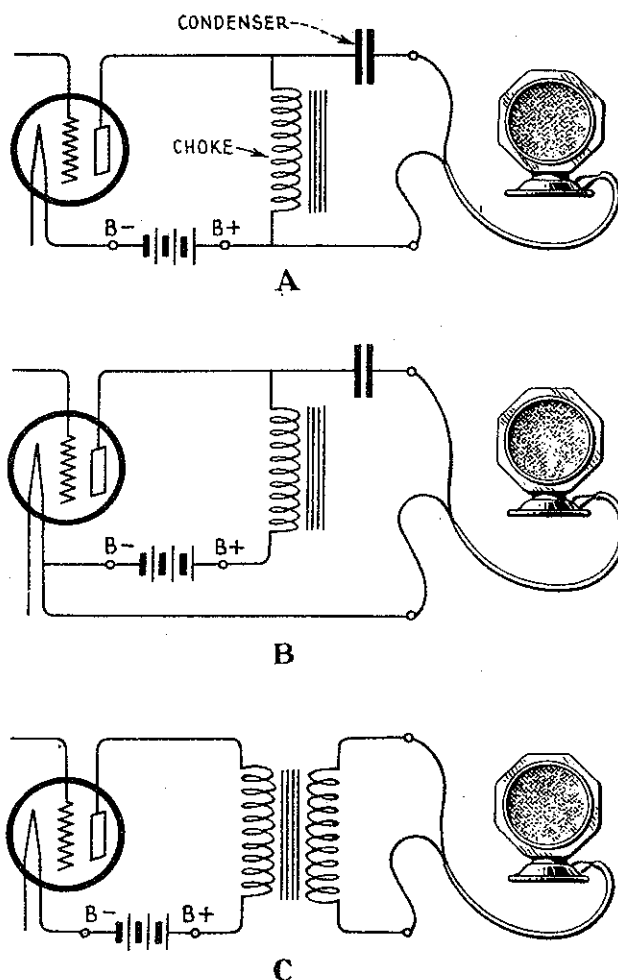
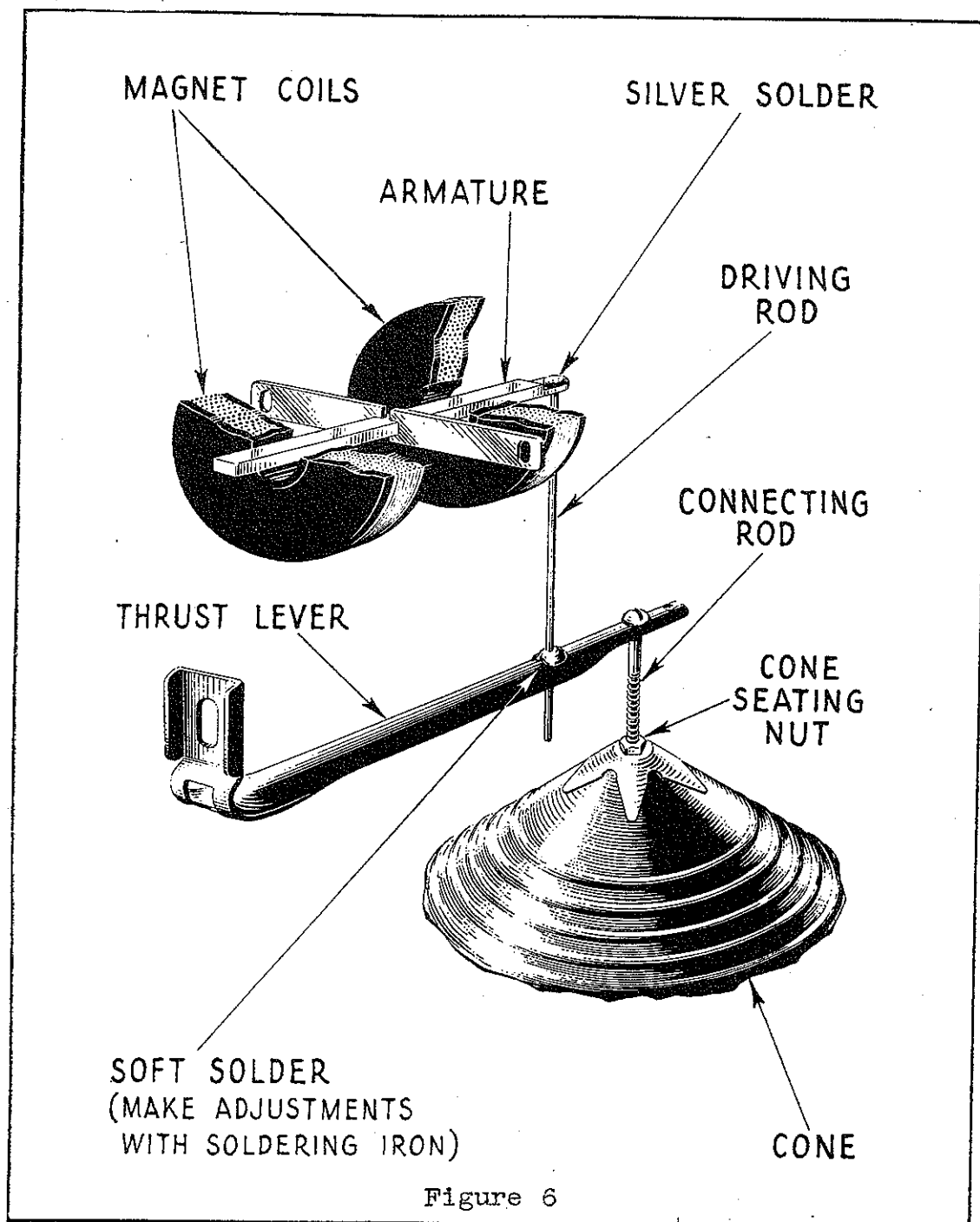


Figure 5

The maximum to and fro motion of the armature is then obtained and thus produces the greatest variation in the cone itself, because of the rise and fall of current of an audio frequency nature in the winding of the armature coil. If plate voltages passing over 10 milliamperes are in effect then some method of coupling the output of the receiver to the loud speaker should be used. Three circuit arrangements to accomplish this result are shown in Figure 5, A, B, and C.

In circuit A if the condenser in the plate lead breaks down the coils of the loud speaker would then be connected in shunt with the choke coil and suffer no injury by passing excessive current. Its disadvantage is that comparatively small values of resistance in the "B" battery supply current will cause a howl in the A.F. amplifier because the current passing through the "B" battery in its return to the negative side of the filament.



In circuit B, Figure 5, it can be readily seen that the current passing through the speaker coils does not have a "B" supply directly connected in the return lead therefore eliminating the disadvantage of circuit A. The disadvantage of circuit B is this; if the condenser breaks down the entire "B" supply would be short circuited through the speaker armature coils which would probably burn them out. The value of the choke to use in making up this output coupling arrangement is an iron core inductance of 30 henries or more having a D. C. resistance of not more than 1,000 ohms. The capacity of the condenser should be from 4 to 8 mfd.

The third scheme of coupling is the use of an output transformer as shown in C, Figure 5. The turn ratio should be 1 to 1 and of suitable design to function properly for this purpose because of the fact that this transformer must carry large values of Direct Current. Magnetic saturation is liable to occur causing unsatisfactory results, therefore correct design is imperative.

The Radiola 100-A and 103 speakers employ a balanced armature unit, operating on the principles just discussed. Figure 6 shows the constructional details of the unit.

LOUDSPEAKER PROBLEMS

Loudspeaker problems confronting the service man may be classed as:

- Distortion
- Noise
- Rattle
- Poor reproduction, or
- No reproduction

If you should be called upon to service speakers the following information will be of material assistance in simplifying the work.

In many instances the loud speaker is considered to be the base of radio reproducing troubles whereas, in reality, the cause lies in the receiver itself hence, as a preliminary measure, it is good practice to make a check by connecting a pair of head telephones in the output of the receiver, determining in this way whether signals are actually coming through and if so whether they are distorted. Since the loud speaker is a reproducing device only, any distortion in the receiver will be duplicated in the loud speaker and the loud speaker cannot be held responsible when the trouble originates in the set. If, on making the head phone test, a signal of good volume and quality is delivered from the set, it then will be necessary to make a close examination of the loud speaker to locate therein the cause of faulty reproduction.

Model 100-A loud speaker consists of a metal housing (cast iron) with an ornamental grille at the front and back, a cone, a frame which supports the permanent magnet, the reproducing motor unit, and a filter system. The 103 speaker is practically identical to the 100-A except in the housing. As a matter of fact all balanced armature speakers operate on the same principle.

To service the 100-A speaker, the reproducing system must be removed from the metal housing. This is a simple operation. Remove the four screws and fiber sheet found at the base of the housing, then, with the left hand, support the mechanism assembly inside the housing, and loosen the four screws holding the grille in place. When these screws are clear the entire unit can be lifted out of the housing. Figure 7 clearly shows this operation.

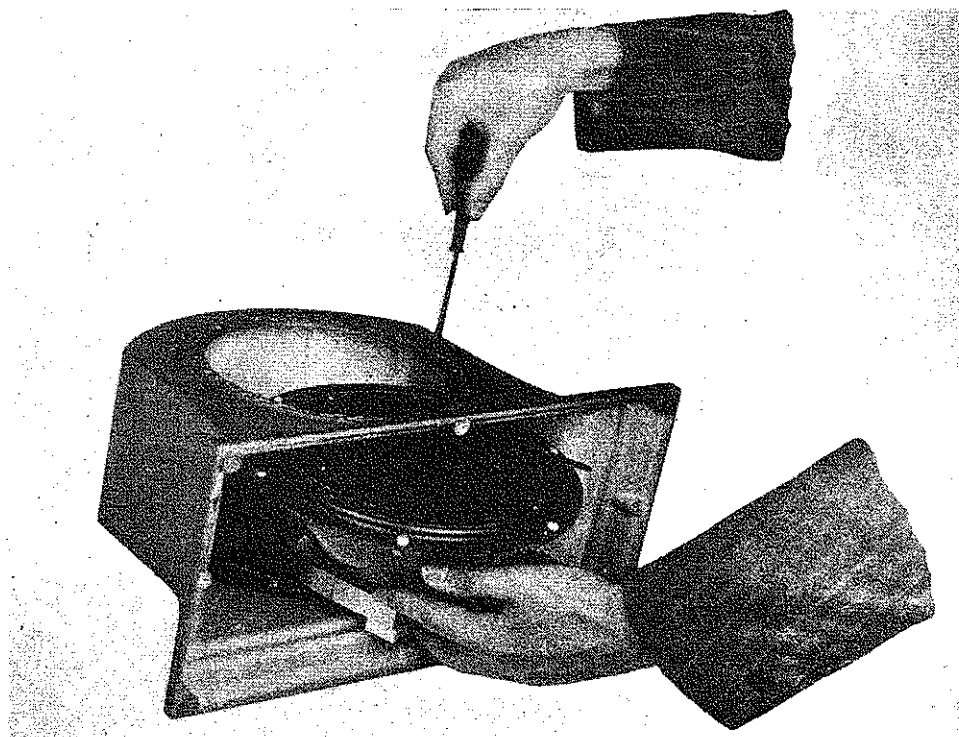


Figure 7

With the unit clear of the housing a thorough inspection can be made. First, examine the motor mechanism to see if dirt or foreign matter has become lodged about the unit in such manner as to cause faulty armature action. Unless the armature operates freely poor reproduction will result. When dirt is found between the armature and pole pieces use a piece of copper or brass, (the maximum thickness of which should not exceed 0.010 inches), or a piece of stiff paper to remove any dirt or foreign matter which might be interfering with the operation of the armature.

DISTORTION OR RATTLES

A unit which rattles or distorts the output of the receiver may be caused by the armature cone or both pole pieces. Such a condition can be usually checked by inspection, but not always. The contact between the armature and pole pieces may be so slight that it cannot be readily determined from inspection. It then becomes necessary to make a careful adjustment of the armature. To properly adjust the armature a set of

special tools are needed which the service man can make easily from the instructions which follow.

The stock for the tools is phosphoreous bronze. From a strip of this material 0.010 inches thick, and 0.25 inches wide, fashion it to resemble the views in Figure 8, carefully observing the measurements given therein. It is necessary to have two of these tools; one is placed in the space between the armature and pole piece of the moving part of the mechanism at the end next to the filter unit. The other one is placed at the opposite end of the armature in such a manner as to clear the driving rod which is located at this end.

With these tools in place, loosen screws A and B as shown in Figure 9. Any tension in either direction that may have been holding the armature in an abnormal position is released and the spacer tools will provide the correct clearance or spacing. In other words, with the spacer tools in place and screws A and B loose, the armature will immediately take up its proper position between the pole pieces.

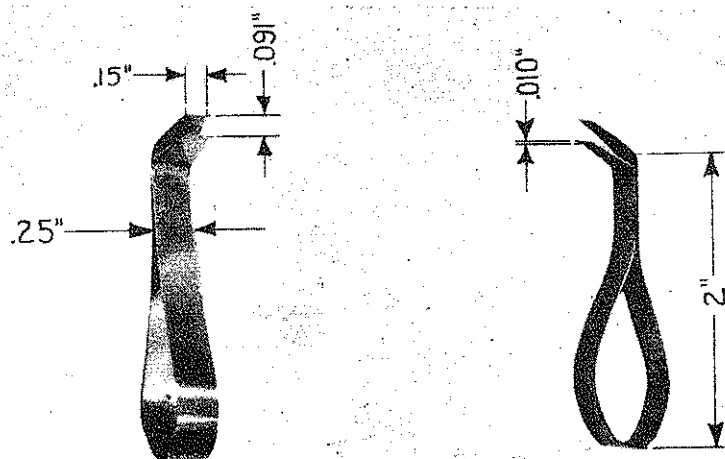


Figure 8

With the above procedure carried out leave the spacer tools in position and apply a hot soldering iron to the driving rod pin at the point where it passes through the thrust lever at point C, Figure 10. Heat the solder at this point until it flows; the connecting rod will now find its normal position relative to the thrust lever through which it passes. Remove the iron and allow point C to cool until solder sets, then tighten screws A and B and remove the spacer tools. If this has been carefully executed the armature should now be in perfect alignment and so balanced that no abnormal tension is being exerted upon it in any direction.

THE CONE

In some installations the cone may be found improperly aligned; this causes a strain to be exerted upon the driving rod due to the cone not centering as it should on the driving rod. Such a condition will be

attended by poor reproduction. This trouble is not likely to be found in a new factory adjusted speaker, but is more liable to be the result of replacing a cone.

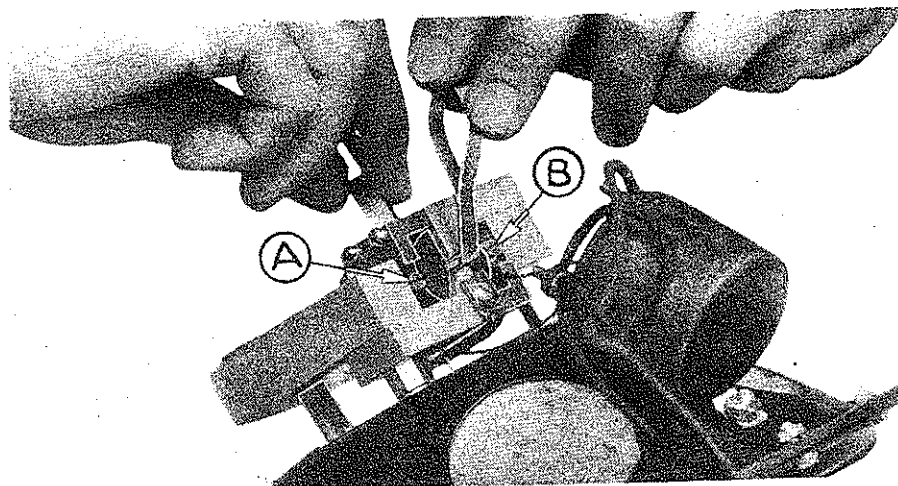


Figure 9

When it is found necessary to replace a cone it should be carefully aligned or seated by first fitting the cone apex over the connecting rod and carefully adjusting the cone seating nut located on the connecting rod close to the thrust lever. Refer to Figure 11. The connecting rod which is threaded on the end and projects through the apex of the cone will now receive a lock nut and washer which should be run on this threaded end but not tightened until the edge of the cone is fastened. The holes around the edge of the cone should now be lined up with the holes in the metal frame and the outside ring lightly attached with six machine screws and nuts provided for that purpose. The nut on the threaded connecting rod in the cone apex is now tightened by using a socket wrench. Once tightened a drop of sealing wax should be dropped on it to prevent it from loosening due to the vibration of the cone.

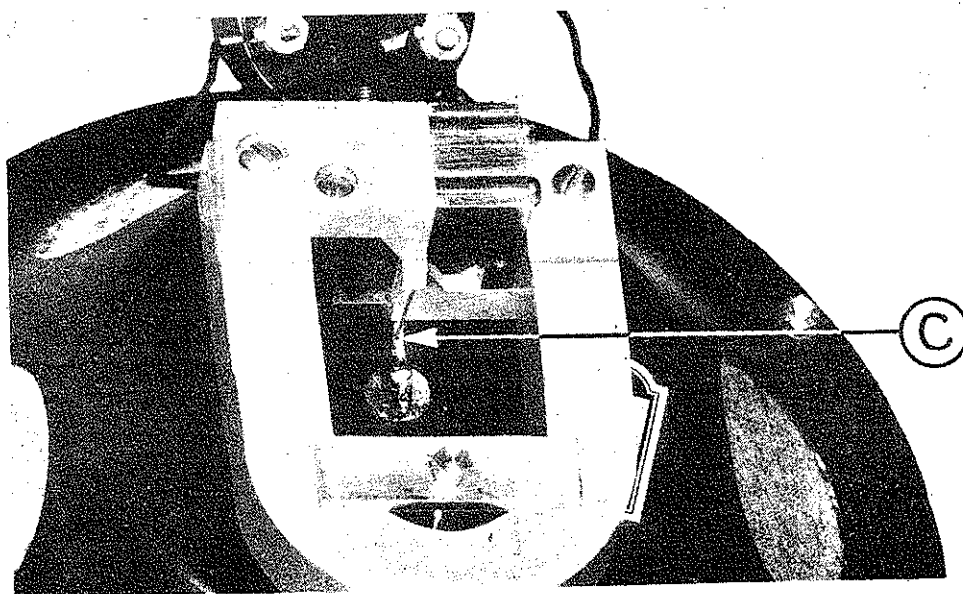


Figure 10

Next tighten the six machine screws successively until they are all tight. When this operation is properly executed the speaker should operate efficiently. Figure 11 shows the position of the six screws and cone tightening nut.

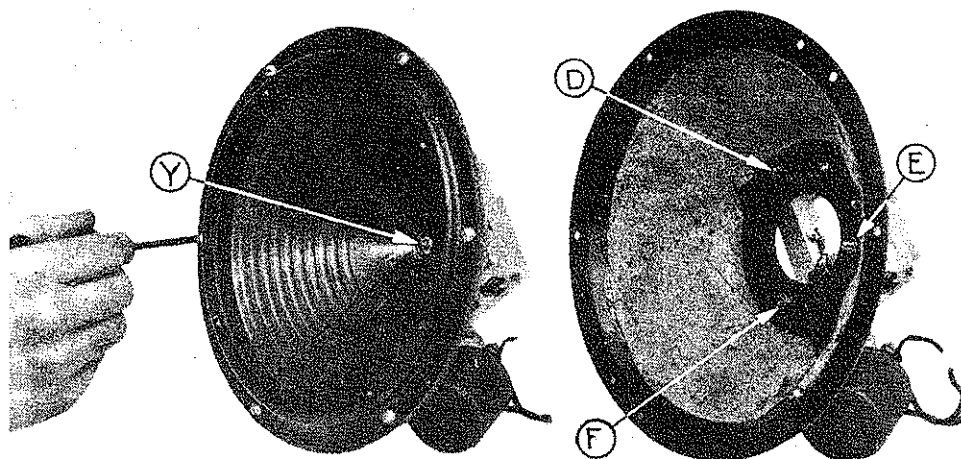


Figure 11

THE THRUST LEVER

The thrust lever shown in Figure 1 may, due to vibration, work loose. This, however rarely occur; if it does noisy reproduction accompanied by a pronounced rattle will be noticed. In correcting this trouble first tighten up on the thrust lever mounting screw shown in Figure 12 at "g". If the tightening of this screw does not clear the trouble a readjustment of the armature as explained under the caption "Distortion or Rattles" should be carried out.

When making an examination of the cone motor mechanism all screws should be inspected for loose parts. A loose nut or screw anywhere on this unit will produce a rattle when the speaker is in operation.

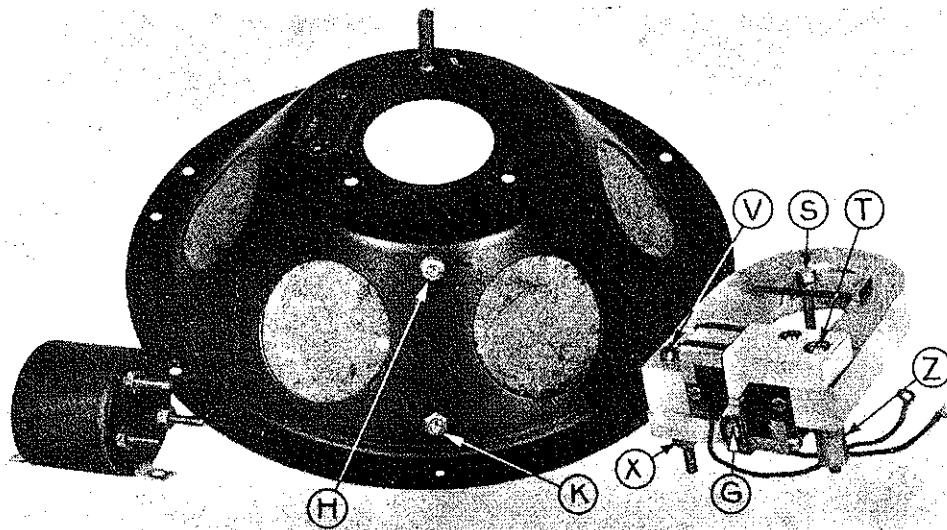


Figure 12

TESTING THE FILTER UNIT AND ARMATURE COILS

A view of the filter unit together with a schematic diagram of the filter circuit connected to the armature coils of the speaker is pictured in Figure 13 showing the proper connections of the filter used with the 100A and 103 speakers. Defective armature coils or a defective filter will cause poor reproduction and if the filter is connected in the circuit contrary to the schematic diagram of Figure 13, distortion will result.

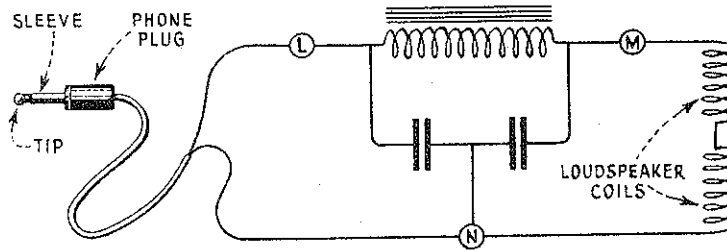


Figure 13

The click test which has been described in previous lessons may be used to test the speaker, armature coils, and the filter circuit. The following chart has been worked out as a guide to the service man and it gives him the results that he should obtain when testing either of these units.

Before testing the filter unit for continuity disconnect the armature magnet coils and the loud speaker cord, then proceed as follows.

With one test tip on	And the other test tip on	The circuit should test	If the circuit tests
Filter terminal L	Filter terminal M	Closed; i.e. a click should be heard	Open, i.e. no click, the coil between "L" and "M" is open
Filter terminal L	Filter terminal N	Open; i.e. no click should be heard	Closed, i.e., if a click is heard the filter condenser between L and N is short circuited
Filter terminal M	Filter terminal N	Open; i.e. no click should be heard	Closed, i.e., if a click is heard, the filter condenser between points M and N is open

The following test is for checking the loud speaker cord and armature coils. When conducting this test see that the armature coil leads of the speaker are connected to terminals M and N of the filter unit and the speaker phone cord is connected to terminals L and N of the filter unit.

With one test tip on	And the other test tip on	The circuit should test	If the circuit tests
The jack tip	First L, then N	If closed when on L then open on N, or vice versa	Open, one side of phone cord is defective or not making good electrical contact at jack or filter terminals
The jack sleeve	First L then N	If closed when on N then open on L or vice versa	Open, one side of phone cord is defective or not making good electrical contact at jack or filter terminals
Filter terminal M	Filter terminal N	Closed	If an open result is obtained it indicates either the armature coils are open or the leads connecting them are broken or otherwise not making electrical contact

Any defective electrical connection in the loud speaker cord or the connections leading to and from the armature coils will cause noisy reproduction and in some instances such defects will result in no reproduction at all.

Due to the fact that there is little wear on the armature coil leads and connections it is unlikely that trouble will arise from this source. However at the point where the cord enters the speaker housing, and the end of the cord which enters the phone plug, there is always a possibility of an open or short circuit developing due to the cord at these points being subjected to excessive wear through handling. In the plug itself the lugs which hold the phone cord terminals become loose or broken after long usage and may cause noise or an interruption of the signal.

When these points have been tested, showing no defects external to the housing of the speaker, the base of the speaker should be removed and the lugs of the cord attached to the filter unit examined. Finding no defect at this point there is but one other test to conduct. Disconnect the phone cord entirely from the speaker and subject it to a continuity test by using a $4\frac{1}{2}$ volt battery and phones and moving all parts of the cord to determine if a break exists in any part of it. A broken cord or loose connection will make itself apparent by a crackling noise in the test phones.